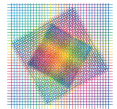


AUDIT II

Topic Report Energy Audit Models

Konstantinos Lytras
Carlos Caspar



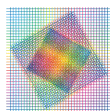
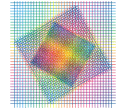


Table of Contents

1	Introduction	3
2	Features Applied To Energy Audit Models	5
3	The Basic Energy Audit Models	7
3.2	The Scanning Energy Audit Models	8
3.2.1	Walk-Through Energy Audit	9
3.2.2	Preliminary Energy Audit	9
3.3	The Analysing Models	9
3.3.1	Selective Energy Audit	10
3.3.2	Targeted Energy Audit	10
4	The Technical Coverage Of Energy Audit Models	12
5	Model Development	13
5.2	Key Decisions In Model Development	13
5.3	Scheduling Model Development	14
5.4	Example: Audit Model Development In Finland	15
6	Recommendations	19

Appendix 1 Examples of Energy Audit Model Applications in Different Countries



1 Introduction

An **Energy Audit** is defined as a systematic procedure that

- Obtains an adequate knowledge of the existing energy consumption profile of the site;
- Identifies and scales the cost-effective energy saving opportunities;
- Reports the findings.

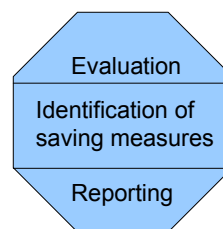


Figure 1.1 The Core Audit

The term Energy Audit as such specifies only in general the content of the working method but does not define the actual scope, thoroughness or aim of the work.

When the energy audit experts in the different European countries were interviewed, several different ways of performing energy audits were found. In practice there are different levels of instructions given for the auditing work. Many of these different approaches fulfil the criteria of a “model”, which is a good term to be used in order to separate the standard procedures from the “do-as-you-like” procedures.

The term **Energy Audit Model** in this context indicates that there are agreed features or requirements designed for a specific type of an energy audit application. In a model the actual scope, thoroughness and aim of the audit are defined.

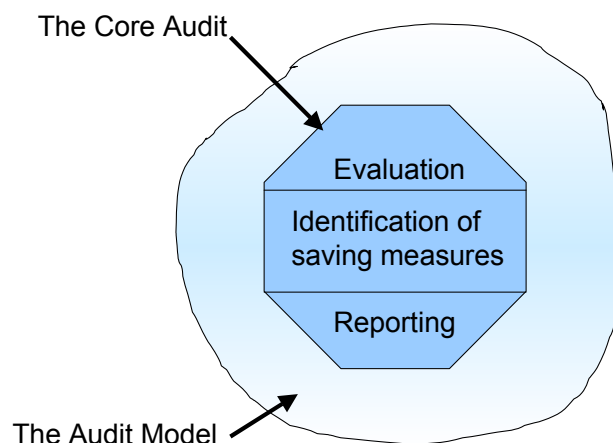
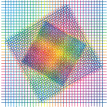


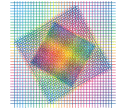
Figure 1.2 The energy audit model around the Core Audit



The audit model is usually a standardised, commonly known and commonly followed procedure with written guidelines. The requirements are usually defined in the guidelines given by the Administrator and/or the Operating Agent.

The main aim of this Topic Report is to give a good picture on the choices the Administrator or the Operating Agent of an energy audit programme have to make when deciding what kind of energy audit models will be taken into use.

There are practical examples on energy audit model development in chapter 5 and in the Appendix showing how different models are used in different countries.



2 Features applied to Energy Audit Models

There are several features that can be applied to all energy audit models. The features are mostly choices from the Administrator's and the Operating Agent's point of view, either on the energy audit programme level or on the audit model level, or both.

Each Energy Audit Model is connected to its cost, time, phasing and reporting characteristics, which should also be taken into account.

These features should not be defined in the audit programme planning phase before a thorough analysis of the need for different audit models. For example defining tight limits for the cost of an energy audit as the first step will certainly lead to difficulties with audit quality, audit volumes and market penetration. If the cost is low, the auditors may not be interested in the business – or will produce very light reports. If the cost is high and no subsidies are available, the clients are not interested.

The features are discussed more closely in the final report of the Audit I –project.

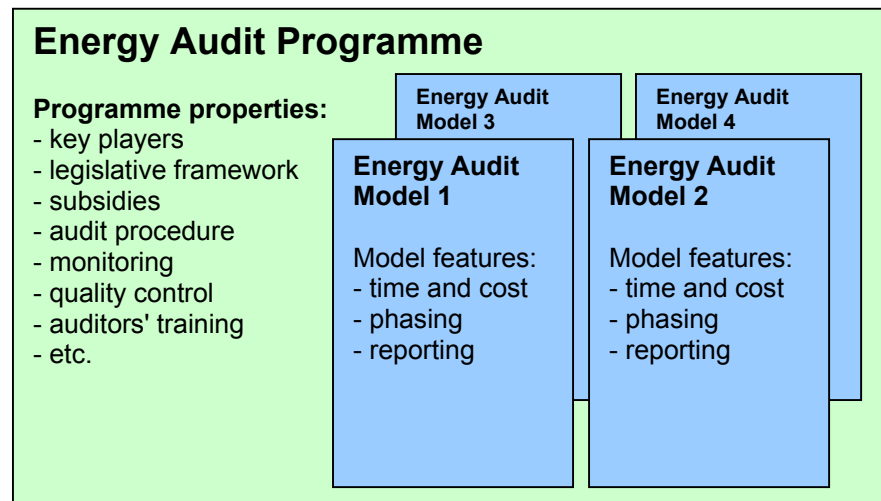
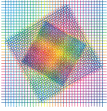


Figure 2.1 Energy Audit Programme Properties and Audit Model Features

The cost of an energy audit is based on the auditors' fee, the labour cost of the client's own personnel or both. The audit cost is typically a model specific feature but has a strong connection to the subsidy policy on the audit programme level. The cost naturally depends on the technical systems and areas of energy use covered in the audit, on the thoroughness of work, etc.

The main options for the audit cost are

- Fixed cost (and/or time of audit work);
- Project specific cost with a maximum limit;
- Project specific negotiated cost;
- Energy savings based cost.



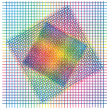
There are different levels for the **reporting** of an energy audit and the options are also closely connected to the thoroughness of the audit work and its cost as well as to the programme level properties of monitoring and quality control.

The main options for the reporting are

- Very light reporting – introducing main results in a summary;
- Simple savings-oriented reporting;
- Detailed technical reporting with background information on energy using systems.

Especially if the energy audit programme is targeted to industry, it may be feasible from the client's point of view to implement the energy audit in several **phases**. A typical approach is to have the first rough audit round, to scan the site, followed by one or several more detailed audits. The selection of the audit models should allow this in order to achieve a good penetration among the clients.

In the building sector a single-phase approach is more practical. The benefit of the single-phase audit is, although the client has bought a slightly bigger package that the auditing process will go to the end on one decision. The more phases and separate contracts there are, the more there are points where the client can decide to stop the auditing process.



3 The Basic Energy Audit Models

An energy audit may cover a site or a building in various ways – the scope of audits may be different. At the “narrowest” an energy audit covers typically only one specific system (or a process) and at the “widest”, an energy audit covers everything inside the site fence. Between these “narrow and wide ends” there are energy audits that deliberately ignore some areas or issues.

The auditor can use “a fine or a rough comb” when looking for the saving potential – the **thoroughness** of audits may be different. The thoroughness of the audit is connected to the audit model, and is normally directly related to the time and cost spent on the project.

Energy audits are used for different purposes, either for pointing out the areas where savings can be found or for describing in detail the actual saving measures so that they can be easily implemented - the **aim** of the audits may be different. This aim may be either scanning the areas of possible energy savings or analysing in detail the individual energy saving measures.

These properties of energy audit models are illustrated in figure 3.1.

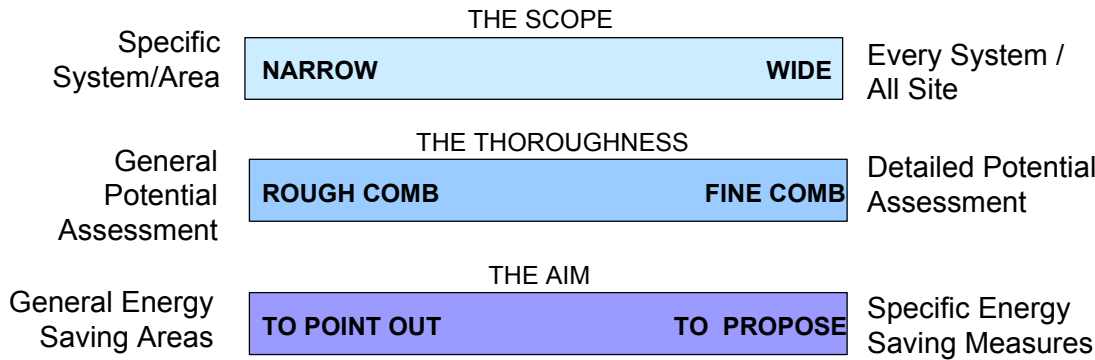


Figure 3.1 The properties of energy audit models

This chapter presents the different energy audit models divided into two main classes according to their aim: to the Scanning Energy Audit Models and to the Analysing Energy Audit Models. Within these two classes the different models have been specified according to their scope and thoroughness. The different basic energy audit models, described in detail later in this chapter are illustrated in figure 3.2.

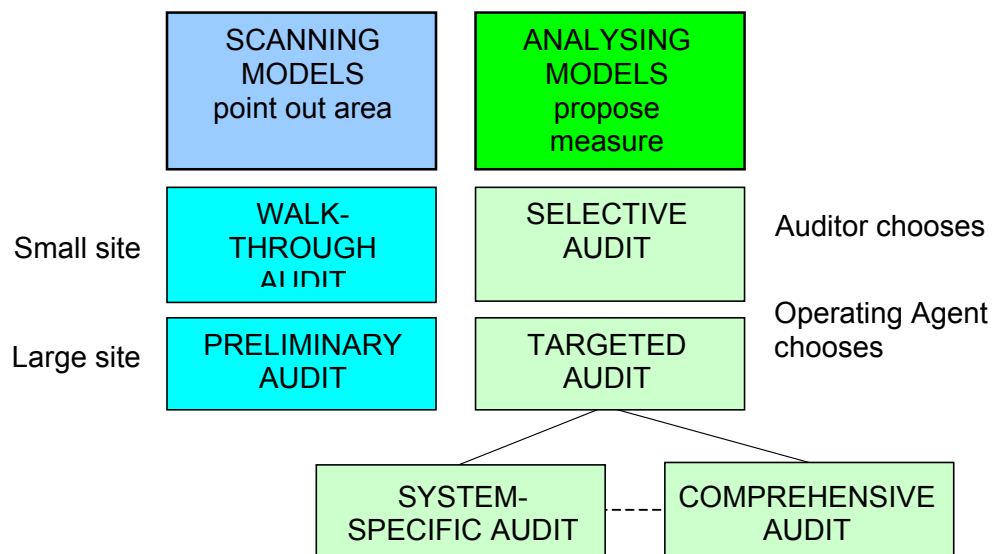
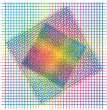


Figure 3.2 Basic Energy Audit Models

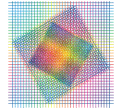
The Basic Energy Audit Models are not very often used as such and therefore the models in actual use are different types of applications of the basic models. The applications have different country- and programme-specific features that form an interface to the connected activities.

3.2 The Scanning Energy Audit Models

The main aim of the Scanning Energy Audit Model is to point out areas, where energy saving possibilities exist (or may exist) and also to point out the most obvious saving measures.

The scanning audits do not go deeply into the profitability of the areas pointed out or into the details of the suggested measures. Before any action can be taken, the areas pointed out need to be analysed further.

A scanning audit model is a good choice if large audit volumes need to be achieved in a short time. These types of audits are usually quite cheap and quick to carry out. From the client's point of view a scanning audit may not bring the expected results, because it does not necessarily bring actual saving measures, ready for implementation but usually suggests further analysis of key areas.



3.2.1 Walk-Through Energy Audit

A Walk-Through Energy Audit is a scanning model typically used in tertiary buildings where the energy consuming systems are quite simple and the probable areas for potential energy saving measures are known in advance. This model is also suitable for small and medium size industrial sites if the production processes are not very complicated in the sense of primary and secondary energy flows.

A Walk-Through Energy Audit gives an overview of the energy use of the site, points out the most obvious savings and also points out the needs for next steps (supplementary “second-phase” audits).

The Walk Through Energy Audit has been used by ESCOs in the scanning phase of Third Party Financing projects.

3.2.2 Preliminary Energy Audit

The scanning energy audit model for large sites is called the Preliminary Energy Audit. Audits of this type are typically used in the process industry.

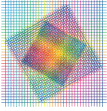
Although the main aim of the Preliminary Energy Audit is in line with the Walk Through Energy Audit, the size and type of the site requires a different approach.

Most of the work in the Preliminary Energy Audit is in building up a reliable breakdown of the present total energy consumption and defining the areas of the significant energy consumption and usually also of the probable energy saving measures. The reporting also points out the areas where supplementary “second-phase” audits are needed and how they should be targeted.

The Preliminary Energy Audit normally needs to be carried out by a team of experts. Expertise is needed both on the auditing procedure itself as well as on the production process. The Preliminary Energy Audit always requires committed participation from the technical personnel of the site.

3.3 The Analysing Models

The Analysing Energy Audit Models produce detailed specifications for energy saving measures, providing the audit client with enough information for decision-making. Audits of this type are more expensive, require more work and a longer time-schedule but bring concrete suggestions on how to save energy. From the client’s point of view the saving potential can be seen and no additional surveys are needed.



The analysing models can be divided into two main types, based on the accuracy and limiting features of the guidelines given by the Operating Agent:

- **Selective energy audits**, where the auditor is allowed to choose the main areas of interest;
- **Targeted energy audits**, where the Operating Agent has defined the main areas of interest.

3.3.1 Selective Energy Audit

For the Selective Energy Audit there are only general guidelines and the auditor is allowed to choose the level of approach, both in coverage and accuracy. The auditor has more or less a total freedom to choose which areas will actually be audited - therefore the results depend on the experience and attitude of the auditor as well as on the budget of the audit work.

The Selective Energy Audit looks mainly for the major savings and does not pay attention to minor saving measures. This audit model is very cost-effective when used by experienced auditors but may in the worst case, be real “cream skimming”. There is always the risk that when a few significant saving measures are found, the rest will be ignored.

From the Operating Agent's point of view this model is problematic because the quality control on this kind of audits is very difficult. If the Operating Agent's aim was to achieve the accuracy and balance of the Targeted Energy Audit and the auditors produce Selective Energy Audits, poor job has been made on the guidelines.

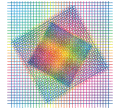
3.3.2 Targeted Energy Audit

The content of work in the Targeted Energy Audit is specified by detailed guidelines from the Operating Agent and this means that most of the systems to be covered by the Targeted Energy Audit are known in advance. The guidelines, set by the Operating Agent, may deliberately exclude some areas. The reason for excluding certain areas may be that they are known to be normally non-cost-relevant.

The Targeted Energy Audit usually produces a consumption breakdown and includes detailed calculations on energy savings and investments. If the guidelines are adequate, the audit produces a standard report.

A tertiary building is an example of a compact site (with more or less standard systems) where this model is a good option but setting very detailed guidelines is not cost-effective in large sites in process industry.

From the Operating Agent's point of view the Targeted Energy Audit is always a risk if the quality control is neglected. If there is no control on the auditors' work, they may be tempted to slowly move towards the Selective Energy Audit, because this model always includes less work.



System Specific Energy Audit

An example of the Targeted Energy Audit at the simplest and smallest is the System Specific Energy Audit. This type of audit has a tightly limited target (one system, device or process), but the thoroughness of the work is usually very high. The benefit of this audit model is that it is possible to have the best expertise on the work, normally better than what an average auditor can provide.

The System Specific Energy Audit produces a detailed description of the system and points out all profitable saving measures with alternative options concerning the specific system.

One good option is combine this kind of audit as a sub-model with some more comprehensive audit models.

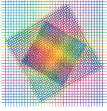
Comprehensive Energy Audit

The Comprehensive Energy Audit is a Targeted Energy Audit at the “widest” end of the scale. It covers all energy usage of the site, including mechanical and electrical systems, process supply systems, all energy using processes, etc. Some minor systems may be excluded but they should be really non-relevant in ratio to the total energy consumption.

The clear difference to the Targeted Energy Audit is that the Targeted Energy Audit deliberately ignores some areas that are known and specified in advance and the Comprehensive Audit covers everything.

The starting point in this type of audit is always an analysis on the detailed breakdown of the total consumption. The Comprehensive Energy Audit comments on all energy using systems specified by the guidelines- regardless if savings are found or not. It points out all profitable saving measures and includes detailed calculations on energy savings and investment costs

This model also creates a basis for a very standard and detailed reporting which brings some advantages to the Operating Agent especially in quality control and monitoring.



4 The Technical Coverage of Energy Audit Models

Depending on the goals of the energy audit programme or activity, the audit models can be defined to cover different aspects of the site. If the main target of the programme is to achieve energy savings, then all energy use should be analysed. However, if the main aim is to promote the use of renewable energy sources, the viewpoint is slightly different.

The technical content of an audit model can be illustrated by a “box-model”. The following examples give an idea of the different approaches:

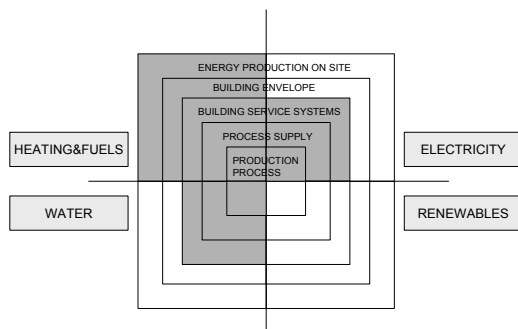


Figure 4.1

The comprehensive energy audit for an industrial site covers all energy use of process, process supply systems, building service systems and heat production.

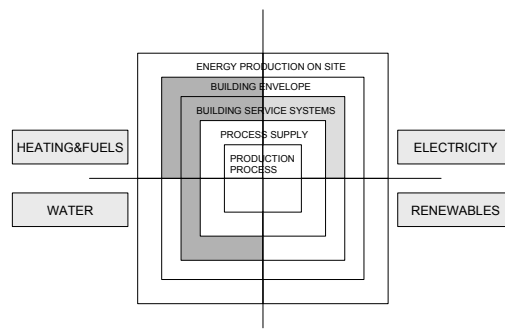


Figure 4.2

In a district-heating connected residential building the energy audit covers building envelope and building service systems. Electricity use of residents is ignored.

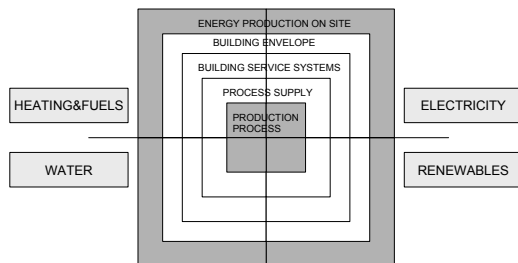


Figure 4.3

In a CHP-power plant energy audit the energy production process is analysed and the possibilities for using renewables are investigated

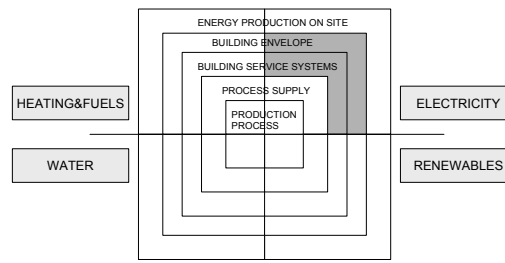
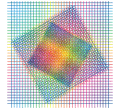


Figure 4.4

If the main focus of the audit activity is to reduce electricity consumption of electrically heated buildings, the audit model is limited to cover only electricity use.



5 Model development

The selection of energy audit models in an energy audit programme depends on various issues:

- The goals of the programme (energy saving, reduction of CO₂, etc);
- The target sectors of the programme;
- The volume goals of the programme;
- The auditors' skills.

The number and type of models is a programme- and country-specific issue and should be considered parallel with the general goalsetting and development of the programme elements.

5.2 Key Decisions in Model Development

The key decisions in model development are introduced in the following.

1. Basic decision: What is the main goal

The initial goal setting of the energy audit programme defines what kind of audit models need to be developed:

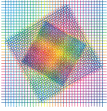
- If the main goal is to point out main areas where savings are likely found – scanning audit models are needed;
- If the goal is to find and propose detailed saving measures (with estimated savings and investment costs) – analysing audit models should be developed.

2. Second decision: One model or several models

When establishing an energy audit programme the programme developers should analyse what are the pros and cons for having just one audit model – will the targets and needs be met?

Advantages of one single model

- Guidelines are simple;
- Clients and auditors will understand the content and coverage easily;
- Auditors can be given a reporting tool;
- Defining the price for audit work is easy.



Disadvantages of only one model

- The model fits only very few sites - clients and auditors will have to adapt;
- Auditors will soon produce different versions for different purposes.

It is not unusual that an energy audit programme has one or two models in the beginning and more models are developed later. It is usually too time-consuming and costly to develop several models when the programme is started - starting with only a few models is a financial compromise.

3. Third decision: Level of guidelines

The guidelines given by the Administrator and/or the Operating Agent describe the audit models – in practice as specifications on content of work, guidance on the field work, checklists and model reports.

When a new model is developed, the level of guidance and auditor material needs to be decided. The more skilled and homogenous the auditors are, the less detailed guidance is needed. If there is a possibility of weak auditors (due to lack of training or other reasons), the more detailed material on the models is needed.

If the number of auditors is small and the auditors are good and the audit targets are heterogeneous, e.g. energy audits in process industry, the guidance should not be too detailed, which in practice would also be difficult to accomplish. Detailed guidance would in this case be too rigid and limit the auditors' opportunity to use their expertise in the most cost-effective way.

The other quite typical situation is that the audit targets are homogenous (apartment houses) but there is a heterogeneous group of auditors working in that field. Then the guidance can and must be detail. Otherwise the results will also be very heterogeneous, which means poor quality.

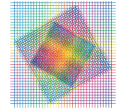
5.3 Scheduling Model Development

If the programme has been started with too few audit models, the needs for new models come rather soon from the auditor and client feedback and also from the quality control procedure.

The programme may also be expanded later to cover new target sectors and there is a need for new audit models to meet the new demands. The programme may also be expanded to deal with additional aspects, such as renewable energy sources, and this will naturally cause changes in the existing models.

The ideal situation for the Operating Agent would be that the new sectors are known well in advance and there is enough time to prepare the guidelines for the new models. The development phase of a new model is 1–2 years, because each new model should be tested in pilot projects before being included in the guidelines.

Once a new audit model has been released, the first submitted reports should be evaluated to ensure that the requirements are met. Even the most experienced auditors may have difficulties adapting a new approach.



Changing the models and their guidelines every year is not recommended – the auditors and clients will be confused by rapid changes.

Figure shows how the model development process works in the Finnish energy audit programme.

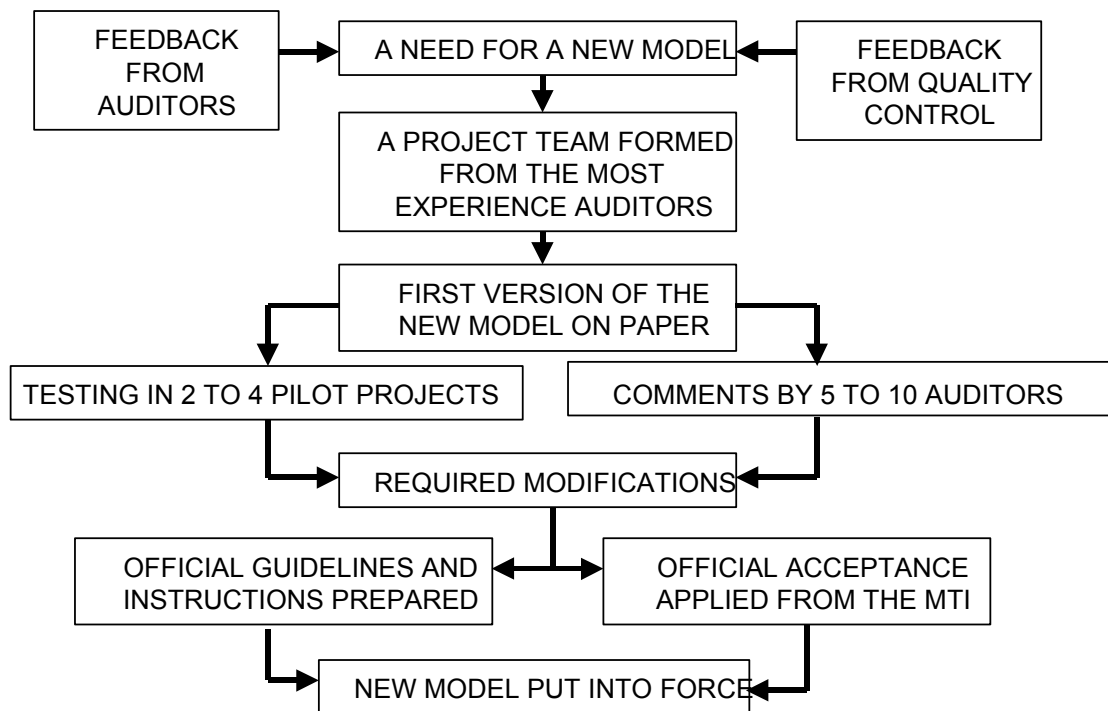


Figure 5.1 The Audit Model development in the Finnish Energy Audit Programme

The models are usually different for different target groups. In heavy industry a multi-phase audit starting with a scanning model is a good option whereas in the tertiary sector comprehensive audits are often used.

5.4 Example: Audit Model Development in Finland

Figure 10 is an example from Finland and illustrates the evolution, which has taken place with the energy audit models. The programme was started as a subsidy scheme in 1992 and developed into a programme level activity during 1993. In 1994 the first energy audit model was published and since then total of 9 new models have been developed and put into force. The reasons why these models have been developed cover probably all possible reasons a programme developer or the Operating Agent can face during the lifespan of an energy audit programme.

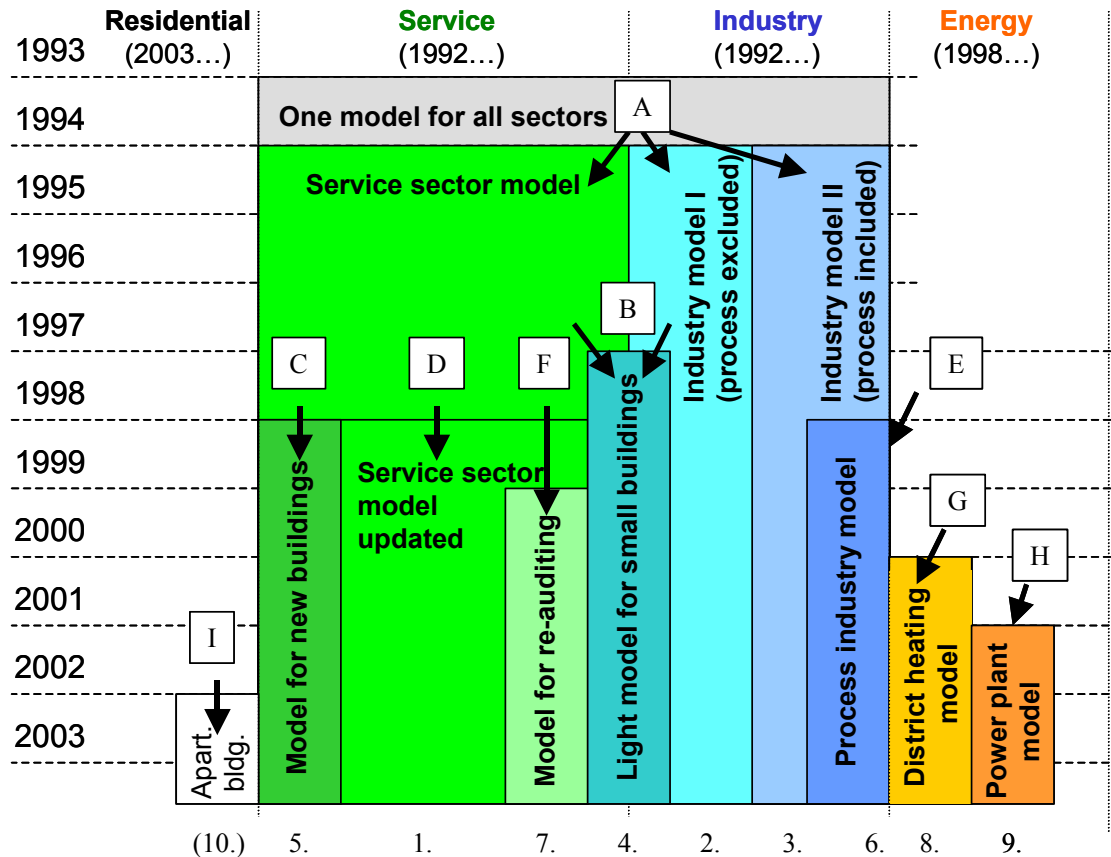
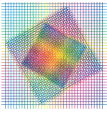
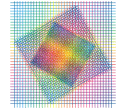


Figure 5.2 Evolution of energy audit models in Finland

Based on the energy audit reports from year 1992 it was clear that a standard energy audit model is needed in order to improve the quality of energy audits. Some 20 % of all reported audits were of poor quality. The first energy audit model was developed in 1993 and published in January 1994, which is also the year when Finland's Energy Audit Programme was launched. Subsidies for energy audits had been available already in 1992 and 1993 but only within a subsidy scheme – not within an actual programme level activity.

A. During year 1994 it became clear that one model couldn't be used in both service sector buildings and in industry. This complaint came from several energy auditors. Based on the energy audit reports from industry the quality control had also found out that the reports are of three different types. One type was concentrating on building itself, which would have been enough for the service sector buildings but not in industry. The other energy audit type had the processes ignored, which in some cases was acceptable but in some cases it was clearly bypassing potential savings. The third type was a comprehensive model where also the process was thoroughly analysed. As a result from these findings three different models were introduced in 1995. The service sector model remained very close to the first model introduced in 1994.



B. The second development phase took place because several auditors complained that the service sector model is too heavy to be used in small buildings. This was really the case and this new model was also allowed in small industrial buildings.

C. The next development started when it became evident that auditing in new buildings is different compared to auditing the old buildings. The idea of having an audit done in the post-acceptance phase to tune the energy consumption into an efficient level had come up already in 1996. Many of the energy saving measures found in old buildings had been causing unnecessary energy consumption from the day the building was constructed. The new model for new buildings was put into force in 1999.

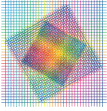
D. The first service sector model, introduced in 1994 had finally come to the end of its lifetime and an updated version was put into force in 1999.

E. The process industry entered the energy audit programme in 1998 as a result of the Voluntary Agreement Scheme signed in 1997. Due to the major differences in this new “subsector” in comparison to medium size industrial companies, there was a need for a new model. This multi-phase energy audit model is quite different in comparison to the other models all of which are single-phase models.

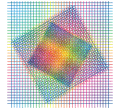
F. For some time there had been a need to upgrade energy audits that had been carried out during the previous years. For clear practical reasons there was no point to demand for complete re-auditing nor to subsidise one. In most of the cases major part of the information presented in the previous audit report was still valid. A model for re-auditing was developed in 1997. The model was thoroughly tested before putting it into force in year 2000. Re-auditing was also made possible in the industry but due to the heterogeneity of the sector no separate model was developed. In industry the auditors are obligated to apply the basic industrial models “the best suitable way”.

G&H. The energy sector joined the Voluntary Agreement Scheme in 1997 and committed itself to carry out energy audits as well. Some hesitation took place before a decision was made to start developing models to this very special area. In 2001 the first energy sector model for district heating systems (G) was introduced. A model for power plants (H) was introduced in 2002.

I. The latest of the models is a model for apartment buildings. A Voluntary Agreement was signed in this sector in 2002 and with the obligation to energy auditing, also required its own model.



Although the number of energy audit models is quite high, there is still a need for new models in the near future. Some specific systems, e.g. the compressed air systems, should have separate models or sub-models because the idea is to use them inside the existing industrial models. There is also a decision to develop a new model to evaluate the potential for renewable energy sources in the municipality areas. In Finland the definition energy audit has become the common nominator or “the family of working methods” under which energy saving measures - and today also the switch to renewable energy sources - can be analysed in various sectors and areas. Good examples from other countries show that the audit methodology can be used also outside the buildings e.g. to assess the savings in street lighting, transportation fleets etc.



6 Recommendations

There are no state-of-the-art energy audit models, but some recommendations to the model developer:

- An energy audit programme will not work properly if there are no clearly defined audit models that fit the needs of the client groups and the skills of the auditors.
- When planning the audit models, the Administrator and Operating Agent should listen to the opinions of the client groups and auditors. Combining the other elements of the programme to the practical audit work needs a thorough analysis.
- An Energy Audit Programme can start "small", that is with only one general Energy Audit Model. Later refinement is possible by developing complementary audit models to adapt to the clients' needs or the marketing options.
- There are various different audit models being used in practice in several European countries. The national experts know the reasons and backgrounds of their models – and they also have the experience which applications have been successful. A model developer should utilise this knowledge!

